January 1, 1927

PROGRAM AND PLAN

of

EUROPEAN CORN BORER INVESTIGATIONS

1926 - 1927

U. S. DEPT. OF AGRICULTURE
Bureau of Entomology

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Arlington, Mass.
Silver Creek, N. Y.
Sandusky, Ohio
Monroe, Michigan
Hyeres, France.

* Supersedes and supplements "Programs" of 1919-1923, inclusive.

I- Distribution.

A - Determination of the actual distribution of the corn borer in the U. S.

1 - One man at each laboratory to determine material sent in by Mr. Worthley's field scouts and quarantine inspedtors. Adults reared to confirm larval determination when material is submitted from new, widely separated, areas - or from new host plants.

II - Control

A - Burning infested material.
1 - By machine.
2 - By various farm methods.
a - Poling and raking. b - Mowing and raking. c - Cutting with "floater" and raking.
(1) - Check effectiveness of various burning methods by computing per cent of living borers remaining in debris; compared to original borer population, per acre. Method - examine all plant debris on soil surface of one sq. rd. in each of 5 representative portions of each field. Indicate volume of debris by linear measure. Include notes on recent history of field.

B - Feeding infested material to livestock.
1 - As ensilage. 2 - Direct from the field. 3 - From the "cutting-box." 4 - From husking machines, equipped with shredder-heads, cutter-heads, or combinations thereof.
a - Check percentage of borers surviving above treatments, by an examination of definite units of treated material, (usually 100 stalks), the larval expectancy previously computed. Important: Retain any living larvae found in treated material, until pupation or death.

C - Plowing infested material.
1 - Experimental sutdies.
a - Autumn series, plowed on various dates from Sept. 15 - Dec. 15.
(1) - Plowing infested cornstalks or stubble, the larval expectancy previously computed, in small areas (16' X 16'). In duplicate series. One series with clean soil surface to simulate clean plowing. The other series with average amount of corn debris on soil surface. Check with small hand burials, with recovery trap adjacent.
(a) - Erect recovery trap at various distances from plowed area i.e. - adjacent, 12.5 ft. distant, 25 ft. distant.
(aa) - Daily examination of recovery trap to determine number and per cent of larvae reaching soil surface and entering recovery traps. Gives data re daily rate of emergence from soil and distance of migration. Does not indicate per cent of survival under field conditions.
(bb) - At close of experiment examine all debris on soil surface for dead or living larvae and pupae. With (aa) this data gives total number and per cent of larvae reaching soil surface.
(cc)- At close of experiment dig up and examine all plowed under portions of cornstalks or stubble, together with nearby soil, for dead or living larvae and pupae. This data will indicate the number and per cent of larvae dying in soil, or not reaching soil surface.
(dd) - Larvae not accounted for in (aa), (bb) and (cc) may be classed as "missing" i.e. - died and disintegrated in the soil, or reached soil surface and were destroyed by natural enemies or weather conditions.

(2) - Plowing infested cornstalks and stubble under field conditions, in strips of approximately 1 acre each. Using newly developed special Oliver plow equipped with 18" bottom and combined rolling coulter and jointer. Determine best adjustment of coulter, jointer and chain, or wire (#9 galvanized) to turn under plant material completely.

(a) - Standing cornstalks without previous treatment.
(b) - Standing stalks after double discing.
(c) - " " " using stalk-cutter.
(d) - Stubble approximately 8" in height.

(aa) - Check effectiveness of each treatment as detailed under A-2-a-(1).

b - Spring series, plowed on various dates from April 1 - May 15.

(1) and (2) - Same as autumn series under a.

c - Status of fence-row, field-border etc, as shelter for larvae migrating from plowed material.

(1) - Place definite number of larvae in typical fence-rows and field-borders. Erect receovery trap around area.

(2) - Daily examination of recovery trap. Return larvae found therein to center of enclosed area.

(3) - At close of experiment examine all plant material within recovery trap. Compute per cent larval survival and adult emergence.

d - Special laboratory studies to determine influences inducing larvae to desert plowed-under host plants.

2 - Field observations.

a - Check effectiveness of fall or spring plowing under farm conditions, using method detailed under A-2-a-(1). Necessitates large scale field surveys to determine larval population in cornstalks or stubble of each field before the plowing operation. (Method of determining larval population detailed under IV-D-1).

D - Time of planting and selection of types, varieties, or or strains of corn - to avoid commercial damage.

1 - Experimental studies in the Middle West (cooperating with agronomists of Michigan State College).

a - Experimental plot.

(1) - On successive dates, plant standard varieties, or strains, or corn used commonly in the region. Record per cent of plants infested, number of eggs and larvae per plant, per cent ears infested, date of maturity, yields etc.

(2) - Develope strains of corn possessing natural resistance to severe corn borer injury, with due allowance for data secured under (1).

(3) - Develop strains of corn which may be planted at the optimum time to escape severe infestation and yet yield profitable returns.

(4) - Test any existing strains of corn, not tested previously, for possible immunity to severe injury under corn borer conditions.

2 - Experimental studies in New England (cooperating with agronomists of Massachusetts Agricultural Experiment Station).

a - Experimental plot. Same as D-1-a (1), (2) and (3).

3 - Field observations.

a - Analysis of effect of time of planting and selection of types, varieties or strains of corn; as shown by data secured in infestation surveys of commercial fields (Method detailed under IV-D-1).

4 - Phenological studies on the development of common trees or shrubs, to correlate plant development with the optimum time of planting to avoid severe injury by the insect and with the seasonal occurrence of the insect. (independent of calendar dates)

a - Choice of plants upon which observations are recorded, dependent upon their importance in the local flora of each region involved: White Oak (Quercus alba); Red Oak (Q. ruba); White Elm (Ulmus americana); Shag-bark Hickory (Hicoria ovata); Norway Maple (Acer platanoides); Red Maple (A. rubrum); Sugar Maple (A.saccharinum); American Beech (Fagus grandiflora); White Ash (Fraxinus americana); Horse Chestnut (Aesculus glabra); Cotton-wood (Populus sp.); Gray birch (Betula populifolia); Stag-horn Sumach (Rhus typhina); Smooth Sumach (R. glabra); Elder (Sambucus canadensis); Concord Grape (Vitis labrusca Hort. var. Concord) and Purple Lilac (Syringa vulgaris).

b - Phases to be recorded: swelling of the buds, bursting of the buds, beginning of leafing out, general leafing out, beginning of blossoming, general blossoming, change in color of foliage, beginning of leaf falling, end of leaf falling, beginning of seed ripening, general seed ripening, beginning of seed falling and end of seed falling.

(1) - Development of plant correlated with curves of temperature and precipitation.

E - Status of host plants other than corn.

1 - Experimental studies in the Middle West.

a - Experimental plats of cotton, millet, the more important sorghums (including broom corn, sugar cane, Sudan grass, Johnson grass), oats, barley, beets, beans, celery, potato, tomato, sunflower, soy bean, cowpea, alfalfa, clover, sweet clover, buckwheat, dahlia, gladiolus, chrysanthemum, cosmos, canna, geranium, golden glow, hollyhock, calendula and zinnia.

(1) - Determine per cent of plants infested by eggs, larvae or pupae, and degree of injury.

(2) - Note distance from growing corn or infested corn remnants.

(3) - Note whether infestation is direct or the result of migration from other plants.

2 - Experimental studies in New England.

a - Same as E-1-a, including only those plants upon which adequate information has not already been secured.

b - Study of plants which may be repellant or toxic to the borer.

c - Study of effect of isolating corn borer on certain susceptible host plants (beets, beans, dahlia, hemp, Polygonum, Xanthium, Ambrosia) to determine whether such plants will support the insect indefinitely, whether there are host plant races and the effect of such isolation upon the insect.

3 - Field observations.

a - Check results secured in E-1 and 2, with commercial plantings. Special reference to information needed for general control, quarantine and scouting.

b - Study of infestation in weeds and large-stemmed grasses.

(1) - Determine per cent of plants infested by eggs, larvae, pupae.

(2)- Note distance from growing corn or infested corn remnants.

(3) - Note whether infestation is probably direct, or the result of migration from corn, or other plants.

F - Special field machinery.

1 - Low cutting devices.

2 - Combination machine to cut low, husk and shred (or cut).

3 - Stubble pulverizer.

a - Check effectiveness of each as detailed under B-1-a.

G - Disposal of infested material in manure pile or barnyard.

1 - [illegible] Animal manure. Mortality of larvae contained in corn, or other plant, remnants when incorporated in animal manure.

a - Entire stalks. b - Portions of stalks. c - Cobs.
d - partially buried. e - Entirely buried. f - Under wet

or moist conditions. g - Under dry conditions. Note origin of manure i. e. - horse, cow, pig, sheep, etc.

(1) - Experimental studies.

(a) - Construct sample conditions as set forth under a to e. Incorporate infested remnants containing definite larval expectancy. Erect recovery trap to intercept migrants. At close of experiment determine larval mortality by detailed examination of treated material.

(2) - Field observations.

(a) - Numerous examinations of corn remnants in manure pile or barnyard under conditions detailed from a to e, preferably in spring just prior to pupation. Note number of living and dead larvae or pupae per 100 ft. of remnants.

2 - Artificial manure. Treat infested corn remnants with alkaline nitrogenous fertilizer.

a - Same as G-1-a to e.

(1) - Experimental studies - Same as G-1-(a).

H - Storage of cornstalks.

1 - Experimental studies.

a - Separate lots of infestad cornstalks stored under cover at intervals from late Autumn to late Spring. Store under various conditions i.e. - warm dry, cold dry, warm moist; in structures excluding precipitation and in structures partly open to the weather.

(1) - Screen each lot, or standard portion thereof, containing definite number of larvae, and observe for emergence of adults. Note per cent larvae developing into adults and dates of emergence.

(2) - Late emerging adults confined in cages to note fecundity and seasonal development of progeny.

2 - Field observations. Checking above, by examination of cornstalks, corncobs etc, stored under various conditions.

I - Trap Crops. (Incidental)

1 - Field observations in Middle West.

a - Check results of previous years on farms, or in localities, where a sequence of planting occurs, and which includes very early planted early maturing corn. Special emphasis upon areas of heavy infestation. Determine per cent of infestation, larval population and damage in corn functioning as a trap crop, compared to later planted corn in the same, or nearby fields. Also analyze results of annual infestation survey, and experimental plot data, on same basis.

2 - Field observations in New Englamd.

a - Same as I-1, with due allowance for 2 generation habit of the insect.

III - Life History, Seasonal History and Habits.

A - Assemble following data re Life History based upon field and laboratory observations. (Listed according to seasonal occurrence).

Note:- Activities listed under III-A are confined to the Monroe, Michigan laboratory, since sufficient life-history data from their respective sections has been secured at the Arlington, Mass., Scotia, N. Y., Silver Creek, N. Y., and Sandusky, Ohio laboratories.

1 - Duration of pupal period.

a - Confine 100 fully grown larvae from the field in small glass-tube cages, just before pupation is expected.

(1) - Note date of pupation, date of adult emergence and sex of adult.

b - If possible, secure similar data from pupae formed under field conditions.

2 - Duration of adult period - note following points.

a - Preoviposition period. b - Oviposition period.
c - Days in oviposition period on which no eggs deposited.
d - Total eggs
e - Fertility of eggs under observation.
f - Hatching (%) " " "
g - Average eggs per day in oviposition period.
h - " " " cluster.

i - Number of clusters.
j - Maximum eggs per day.
k - Postoviposition period.
l - Longevity, male and female.

Note:- To obtain this data start at least 50 flower-pot lantern-globe cages containing material on which to obtain oviposition (a small corn plant or other favorite host in a bottle of water). Provide moisture for the adults to drink. Count number of eggs accurately under d and h. Be sure to examine glass sides of cage, cheese cloth top, and large particles of soil on surface as well as host plant. When eggs are deposited on host plant or other transferable medium, such eggs should be placed in a salve-box and given a serial number under the Index No. for "Egg-Incubation" (1.12-1) and entry should be made in the adult cage notes of the disposition of the cluster of eggs. A separate salve-box each day for each adult cage when eggs are found therein. A moist piece of white blotting-paper in each salve-box. Notes accompanying each salve-box should show date eggs oviposited, number of clusters and total eggs therein. Examine salve-boxes each day and note when hatching occurred. These salve-box cages will show "Duration of Incubation" period and render unnecessary a separate set of cages for this purpose. Several days after eggs have hatched or when time is available examine contents of each cage for unhatched eggs, which will give data under e and f. A tabulation of the notes for each adult cage and accompanying salve-boxes will give all data listed under 2 and the incubation period in addition.

3 - Duration of egg period.
a-Fully covered under B - 2. Construct a separate table, however.

4 - Duration of the larval period.
a - Determine larval instars, both number and duration, of 100 larvae.

Note: Attempt to carry through about one-third of this work with each the early, midseason, and late larvae -- in order to distribute the time element and also to note differences in the length of time required for passing through the various instars at different times during the season if such differences occur.

B - Assemble following data re Seasonal History based upon field and laboratory observations. (Listed according to seasonal occurrence). With special reference to information needed for control, quarantine and scouting operations.

1 - In the Middle West - (one generation).
a - Pupae (from overwintering larvae) in field and in cages
(1) - Date of first occurrence, progress (percentage), and last occurrence essential.

Note: Field collections (or examination of material kept under natural conditions) at frequent and regular intervals (3 days for example) beginning approximately May 10. If possible each examination should be based upon a standard, definite number of individuals.

(2) - Note winter mortality, disease, parasites, predators, etc. during progress of field dissections.
b - Adults - in field and in cages.
(1) - Same procedure as in a - (1).

c - Eggs - in field and in cages.
(1) - Date of first, maximum and last occurrence in field.
Note: Occurrence and hatching of eggs in the field can be quite accurately estimated from data secured under B-1-a-(1) and b (1) in conjunction with duration of preoviposition period of adults and incubation period as secured in adult cages under A-2, but it is desirable to obtain as many actual field records as possible.
d - Larvae - in field and in cages.
(1) - Date of first occurrence.
(2) - Date when last instar larvae of summer brood are present in the field.
(3) - Date when these larvae become numerous.
(4) - Approximately the date when majority of larvae cease feeding and become mature.
e - Number of generations.
(1) - Special field observations to determine whether more than one generation develops in the field.
(a) - Examine early planted corn (about Aug. 15) for pupae.
(b) - Examine late planted corn for eggs or early instar larvae (late Aug. or early Sept.)
(c) - Note pupae, or pupal cases, indicating summer pupation, found during progress of general or special dissections.
f - Phenological studies on the development of common trees or shrubs to correlate with seasonal occurrence of the insect - as detailed under II-D-4.
g - Study of influences responsible for variations in number of generations in different areas within World distribution of the insect.
(1) - Biological, meteorological, ecological studies in U. S.
(a) - Rearing two generation material originating from New England, at Silver Creek, N. Y., in large field cages.
(b) - Cross-breeding and rearing (in large field cages) of (aa) - Single generation females and two generation males.
(bb) - Single generation males and two generation females.
(c) - Completed studies indicated in Appendix.
(2) - Biological; meteorological, ecological studies in Europe.
(a) - Detailed in section VI(Investigations in Europ

2 - Seasonal History in New England (two generations)
a - Spring pupae (first brood)- in field and in cages.
(1) - Same procedure as B-1-a-(1).
(2) - do
b - Adults (first brood)- in field and in cages.
(1) - Same procedure as a- (1).
c - Eggs (first brood)- in field and in cages.
(1) - Same procedure as B-1-c-(1), except that New England records for duration of stages should be used.
d - Larvae (first brood) - in field and in cages.
(1) - Same procedure as B-1-d-(1) to (4).
e - Summer pupae (second brood)-in field and in cages.
(1) - Same procedure as B-1-a-(1).
f - Summer adults (second brood)- in field and in cages.
(1) - Same procedure as B-1-b-(1).
g - Summer eggs (second brood)- in field and in cages.
(1) - Same procedure as B-2-c-(1).
h - Overwintering larvae (second brood)- in field and in cages.
(1) - Date of first occurrence.
(2) - " when last instar larvae are present in the field.
(3) - Date when these larvae become numerous.
(4) - Approximate date when majority of larvae cease feeding and become mature.

i - Special field observations to determine the proportion of single and two generation individuals.
Note: The percent of summer pupation (indicating 2 generations) varies from year to year, dependent upon meteorological conditions.
(1) - Dissection of early and mid-season planted corn
(2) - " " " " " " maturing weeds
(3) - Analysis of any cage rearings under way.

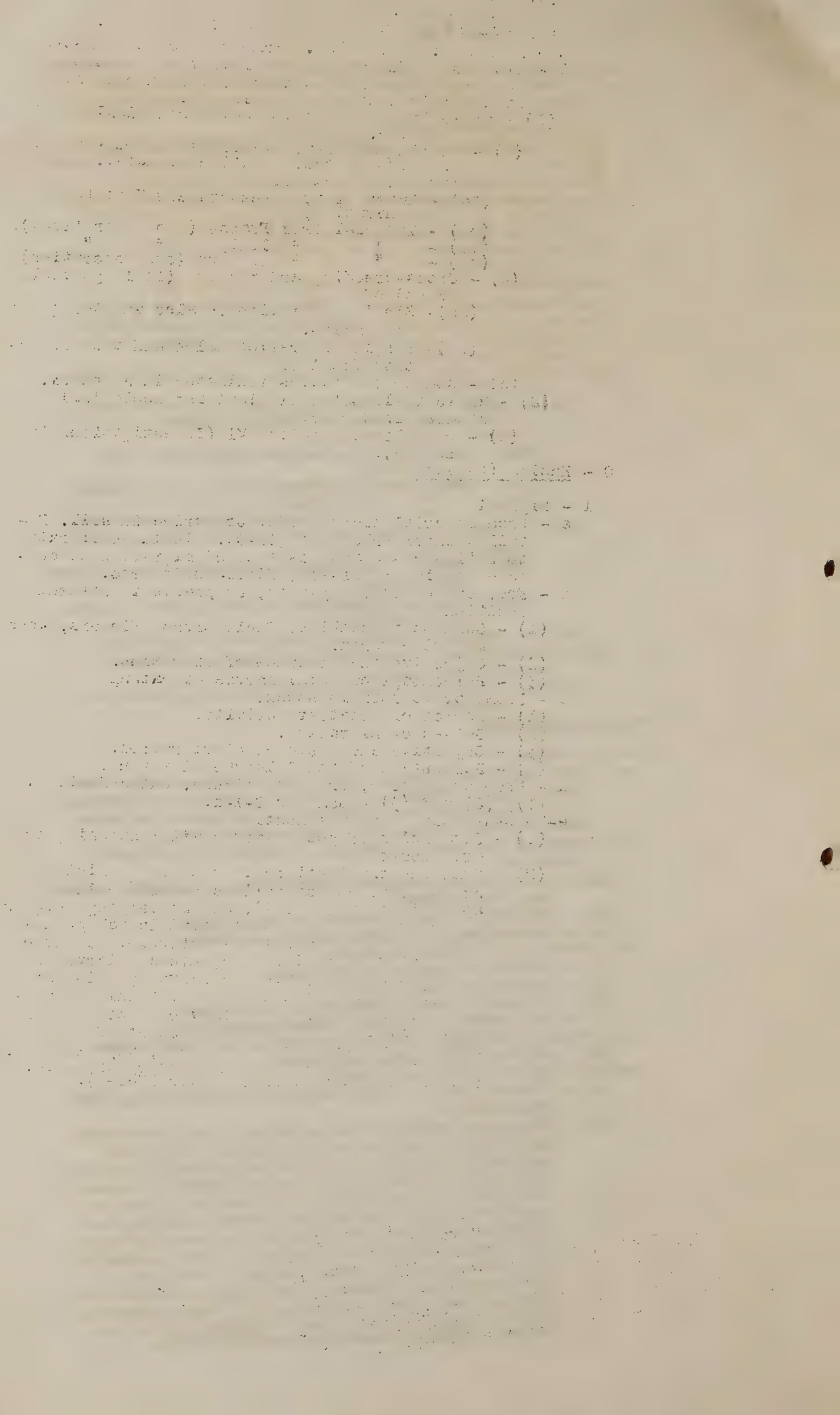
j - Special observations to determine possible occurrence of 3 generations. Note: Third generation individuals developed in 1918 and 1921.
(1) - Dissection of late planted corn or late maturing weeds.
(2) Analysis of any cage rearings under way.

k - Phenological studies. Same procedure as B-1-f.

l - Study of influences responsible for variations in number of generations in different areas within World distribution of the insect.
(1) - Biological, meteorological, ecological studies in the U. S.
(a) - Rearing material originating from several different areas, at Waltham, Mass., in large field cages.
(aa) - Material from western New York (one generation)
(bb) - Material from France (two generations).
(cc) - " " Italy " "
(dd) - " " Hungary (one generation).
(b) - Cross-breeding and rearing (in large field cages) of
(aa)- Single generation females and two generation males.
(bb)- Single generation males and two generation females.
(c) - Completed studies indicated in Appendix.
(2) - Biological, meteorological and ecological studies in Europe.
(a) - Detailed in section VI (Investigations in Europe).

C - Habits (Larvae)

1 - Migration
a - From material plowed under or buried in soil. Detailed under "Plowing" (II-C). Includes migration to soil surface and distance of migration to surface debris, fence-row, field-border etc.
b - From or to growing plants, or plants in natural position
(1) - Corn to vegetables, field crops, flowers, weeds and vice versa.
(2) - Objective and distance of migration.
(3) - Percentage of total larvae migrating.
c - From, or to corn in stock. (shock)
(1) - Period of greatest activity.
(2) - Causes of migration.
(3) - Objective and distance of migration.
(4) - Percentage of total larvae migrating.
d - From or to corn, or other plants, cut and piled.
(1), (2) and (3) - Same as C-1-c.
e-To other parts of same host.
(1) - Dispersion of young larvae after hatching from egg-cluster.
(2) - Numerous examinations in stubble of field and sweet corn, cut at various dates (beginning approximately Sept. 1), and at varying heights, to determine per cent of total larval population of field remaining in stubble. Compute per cent stubble infested, average larvae per infested stubble, average larvae per 100 stubble (infested & non-infested), total larvae in stubble per acre, total larvae in stubble of entire field. Note average height of stubble whether hand-cut or machine cut, approximate date of cutting and recent history of field. (Method same as detailed under IV-D-1).



Note: Usually a pronounced movement of larvae, to the lower part of the stalk, occurs during the late summer and early autumn.

(3) - Conditions favorable for migration to ears.

f - Influence of natural or artificial barriers in preventing or limiting migration.

g - Daily and seasonal period of greatest migration.

h - Meteorological influences affecting migration.

i - Migration to plants, or inanimate objects, for shelter. i. e. - Grape vines, black-berry canes, wind-fall fruit, under loose bark of trees loose leaves, sod, fences, buildings etc.

(1) - Determine whether such larvae pupate and develop adults.

j - Migration, mortality and establishment of newly hatched larvae. Detailed under C-3-c.

k - Special examinations to trace migration of larvae from upper to lower portion of stalk. Standard unit of stalks cut at 3 inch intervals from 3" to 24" in height every 2 weeks between Sept. 1- Nov. 1. Note per cent of total borers in entire plant remaining in such stubble.

2 - Hibernation.

a - In locations detailed under C-1-i.

b - In normal location within host plant.

c - " shelter plants, upon which larvae do not feed.

d - Mortality during hibernation.

(1) - Experimental studies.

(a) - Isolation of sample lots of cornstalks, or other host plants, larval expectancy previously computed, in locations representing different ecological influences. Compute per cent mortality.

(b) - Compute per cent mortality in locations represented by 2 - a to c inclusive.

(2) - Field observations.

(a) - Note per cent winter mortality under natural conditions. Taken incidentally during all field observations and dissections.

e - Study of factors influencing hibernation, under controlled conditions, indicated in Appendix.

f - Meteorological influences affecting hibernation.

(1) - Precipitation, temperature and seasonal distribution of the same.

3 - Mortality.

a - During hibernation. Detailed under C-2-d-(1).

b - " remainder of the year. Same as C-2-d-(2).

c - " establishment of the young larvae.

(1) - Experimental studies.

(a) - Detailed observations on egg-clusters deposited on different types, varieties and strains of corn, and other susceptible plants, to determine the relationship, if any, between larval mortality and the host plant selected for egg deposition. Particularize on different portions of the plant. Count eggs in each cluster, and determine per cent of larvae which become established and reach maturity.

(b) - Small plats of corn representing standard types, varieties and strains planted on successive dates and infested artificially with definite number of eggs. All naturally deposited eggs removed. Data secured as detailed in 3-2-(1)-(a).

(c) -Duplicate series. Same as (b) except that plants are subjected only to natural infestation.

(d) -Ability of larvae to hatch and reach plant from egg-clusters dislodged from plants and falling to soil surface.

(e) - Special observations to determine per cent of larvae reaching maturity from eggs deposited on corn, planted after June 10. (Refers to proposition of universal late planting).

(2) - Field observations.

(a) - Detailed observations similar to 3-c-(1)-(a) and (c), in commercial fields. Isolate blocks of plants in representative portions of commercial cornfields. All natural infestation.

d - Mortality caused by exposure to direct rays of sun. (Include observations on eggs and larvae under natural conditions).

e - Meteorological influences affecting mortality.

(1) - Precipitation, temperature and seasonal distribution of the same.

D - Habits (Adults)

1 - Selection of plants for oviposition as detailed in preceding sections.

2 - Oviposition habits of adults as affected by meteorological conditions (supplemental to previous investigations indicated in Appendix)

3 - Dispersion of adults as affected by winds supplemental to previous investigations indicated in Appendix)

(Section IV on page 10)

IV - Dispersion

A - Flight - as noted under III - D - 3.
B - Relation of artificial and common carrier to dispersion.
1 - Continuation of investigations relative to transportation of eggs, larvae, pupae or adults in commercial products.
C - Relation of water-drift to dispersion of host plants or waste commercial residues.
1 - Continue investigations relative to water-drift of infested material in lakes, rivers, etc.
2 - Special attention to water-drift of infested material from HEADWATERS and along the banks of large rivers draining, or passing through, non-infested territory.
D - Dispersion as indicated by status of infestation.
1 - Field surveys in selected, representative townships in older portion of each infested area (New England, eastern New York, western New York, Ohio, and Michigan). Such surveys to be made in the same, or nearby, fields each year. Object is to trace the annual development of infestation from year to year, since the borer was discovered, and to serve as an index of the probable ultimate status of the insect as a pest. Five fields to be surveyed in each township, such fields originally selected at random. One hundred consecutive plants to examined for infestation in each of five representative portions of the field. A total of 500 plants. Each unit of 100 plantsselected at random, one unit in center of the field and one unit in the center of each quarter of the field. Dissect 10 infested plants per field to determine average number of borers per infested plant. (Limited to 10 plants because of owner objections and time consumed). Include following data on special forms:
a - Date of observation and observer.
b - State, county, and township.
c - Name and address of grower.
d - Type and variety of corn.
e - Date planted.
f - Stage of growth when examined.
g - Number plants examined.
h - " " infested.
i - Number rows in field and average plants per row.
j - Approx. acreage in field.
k - Number infested plants dissected and average larvae per infested plant.
l - Maximum larvae per infested plant.
m - Estimated yield of field (excellent, good, average, or poor).
n - Character of soil.
Note: Same method and form to be used in field surveys to determine % infested cornstubble and ears.
(1) - Tabulate and summarize to show % plants infested, average larvae per infested plant, average larvae per 100 plants (infested and non-infested) in each field, township, county, and state.
2 .....Field surveys to include entire infested area in Middle West. For this purpose the infested area of Michigan, Ohio, Pennsylvania, and western New York will be "checkerboarded" on a township basis. Indicated townships are surveyed. The data secured in the survey under D-1 is also included.
a to n - Same procedure as in D-1-a to n.
(1) - do.
o - Classify infestation according to ecological influences.

(1) - Types of soil, flora, fauna, terrain, river valleys, hill country, water-courses, flood plains, etc.

3 - Field surveys (new England) in fields of economic hosts other than corn (beets, beans, celery, etc.) using same procedure as above.

4 - Special field survey in New England to determine % of ears infested and economic loss in commercial plantings, with corn using same procedure as above.

5 - Special field surveys to determine % of weeds infested. Confined to the more susceptible species.

6 - Classification of infested area according to the intensity and character of the infestation. The approximate size of the area in each class to be indicated and mapped. Compare relative size of area in each class and its distribution from year to year.

a - In the Middle West.

(1) - Class I - Area in which corn and a small % of susceptible weeds and economic plants other than corn are infested.

(2) - Class II - Area in which the infestation is confined almost exclusively to corn.

b - In New England.

(1) - Class I - Area in which corn, weeds, grasses, flowering plants, and crops other than corn are heavily infested.

(2) - Class II - Area in which the infestation is confined principally to corn with a small % of infestation in susceptible economic plants other than corn, and in weeds.

(3) - Class III - Area in which the infestation is confined almost exclusively to corn.

7 - Indirect injury and commercial loss to corn.

a - Reduction in number of ears due to injury to plant.

b - do. weight do.

c - do. quality do.

d - do. quality of grain do.

e - Effect on viability of seed.

V - Host Plants

A - Continue list of all economic and non-economic plants found infested. The list should be arranged alphabetically and systematically.

1 - Host plants classified according to

a - Relative susceptibility.

b - Nature of infestation.

c - Frequency of occurrence.

d - Stages of insect involved (generation in New England)

e - Portion of plant attacked.

f - Designate whether each plant on list is probably a true food plant, a shelter plant, or both.

2 - Secure authentic determination of each new host plant and of the insect found therein.

B - Exhibit material.

1 - Herbarium of all host plants, including summer, and winter condition (seeds, fruit, etc.).

2 - Jars of preservatives containing each species and important variety and showing typical infestation in each.

3 - Photographs of plants, or portions thereof, showing typical infestations.

C - Seasonal abundance of the insect in each of the more important host plants according to

1 - Condition of plant.

2 - Durability of plant for protection.

3 - Due to abandonment of plant for new food supply.

4 - Due to occurrence of first and second generation (New England).

D - Portions of plant attacked as related to seasonal growth of plant and seasonal development of insect.
E - Duration, extent, nature, and appearance of infestation.
F - Proportion of plants attacked in heavy, medium, and light infested areas.
G - Relation of certain plants to vitality and future development of insect.
  a - Directly
  b - At the end of several generations. (Detailed under II - E - 2 - c).
H - Examine all plants suspected of functioning as host plant
I - Study plants which may be repellant or toxic to the borer

VI - Investigations in Europe (K. W. Babcock and assistants)

A - Distribution.
  1 - Checking of recorded distribution and scouting of suspected new areas, not previously recorded.
B - Seasonal History.
  1 - Collect data in Hungary, Yugoslavia, Roumania, Czechoslovakia, Italy, France, Germany, Spain, Belgium, and Poland.
    a - Seasonal history observations in important areas. Essentially same method as detailed in III-B.
    b - Collection of data relating to separation of seasonal cycle zones; particularly important for obtaining data dealing with the development of various habits accompanying a change of seasonal cycles.
      (1) - Important regions showing the merging of two-generation into a one-generation area and vice versa.
      (2) - Important regions exhibiting reaction of the insect to radically different types of climate (temperate; warm, dry; cool, dry; semi-arid; under irrigation, etc.).
    c - Collection of data in typical one-generation area.
    d - do. two-generation do.
C - Abundance and Damage.
  1 - Collect data from countries listed under B-1, with special emphasis on work in Central European Corn Belt where conditions are essentially similar to those existing in our middle Western states.
    a - Note % of infestation and damage to stalks, ears and larval populations, type and variety of corn involved, date of planting and harvesting, condition of corn. Abundance of eggs and small larvae secured in early season observations.
    b - Infestation and damage to economic crops other than corn.
      (1) - Note whether such infestations are associated with, or independent of, corn.
    c - Infestation in weeds.
      (1) - Same as C-1-b-(1).
D - Host Plants.
  1 - Economic
  2 - Non-economic.
E - Parasites (in cooperation with Hyeres, France, laboratory)
  1 - Records of parasitism encountered during numerous dissections involved with field work.
  2 - Records of parasitism from special sections, or areas designated by Dr. Thompson of Hyeres laboratory.
  3 - Systematic collection, and subsequent dissection for parasitism, of various stages of the insect. Such collections made in areas where the abundance of the insect, or other considerations, warrant the same.
F - Natural Enemies Encountered Other Than Parasites

G - Control
1 - Measure effectiveness of control methods practiced, by an examination of debris remaining in fields at close of treatment.
a - Procedure same as detailed in II-A-2-a-(1).
2 - Measure effectiveness of special control measures practiced, not adapted to G-1-a.
3 - General observations relating to methods and effectiveness of control measures practiced.
a - Analyze data from field infestation surveys to show effect of time of planting and use of types, varieties and strains of corn.
b - Same procedure for other economic crops.
H - Meteorological records with special emphasis upon data, needed for proper intrepretation and correlation of biological and economic data secured during investigations.
I - Agricultural records with special emphasis upon cultural methods, crop rotations, phenology, associated insects, etc., needed for proper interpretation of biological and economic data secured during investigations.

VII - Investigations In The Orient.

Note: In cooperation with Japanese Beetle Investigations
A - Continuation of present investigations with same general plan as outlined under VI.
1 - Biological observations.
2 - Economic "
3 - Ecological "
4 - Parasites.
a - Shipment to the U. S. of those species which investigation may demonstrate as suitable for trial in this country.

VIII - Natural Enemies.

A - Parasites (Investigations in U.S.)
1 - Foreign.
a - Importation of parasites from Europe (See VIII-B-2 and 3).
(1) - Store material and rear parasite adults at proper time indicated.
b - Liberate all adults not required for laboratory breeding.
(1) - New England
(2) - New York
(3) - Pennsylvania
(4) - Ohio
(5) - Michigan
(6) - Indiana.
(a) - Precautions to prevent possible escape of hyperparasites.
c - Allot quota of material to cooperators at Dominion (Canada) Parasite Laboratory, Chatham, Ont.
Note: 1926-1927 importations are expected to exceedthose of 1925-1926 in which two parasite species (Eulimneria crassifemur Thom.) and (Microgaster tibialis Nees.) arrived in the cocoon stage; together with approx. 500,000 corn borer larvae from which were reared 5 species of parasites viz: (Apanteles sp , Macrocentrus sp., Angitia punctoria Roman, Zenillia roscanae B.B. and Masicera senilis Rond.). A pupal parasite (Phaeogenes planifrons Wesm.) arrives in large numbers in the summer shipments.
d - Laboratory breeding of parasites for liberation, using imported adults for breeding stock.
(1) - Special campaign to produce large numbers of Apanteles sp. and Microgaster. Using methods already developed.

(2) - Perfection of above methods to increase economy and efficiency.
(3) - Development of breeding technique for six other available species through studies of their habits.
e - Recovery of above imported species in the field.
Note: Five species of the ten species liberated have been recovered in the field at the close of the 1926 season.
(1) - Bulk collections of infested cornstalks placed in screened insectaries. Collect all parasites emerging therefrom. Determine species of imported parasites involved and compute their abundance and status in natural control.
(2) - Small collections of host larvae placed in cages. To determine more accurately the % of parasitism, rate and direction of parasitism, etc.
2 - Native Parasites.
a - Continue observations and comparisons re native species.
(1) - Special collection of host eggs to determine effectiveness of Trichogramma minutum Riley.
(2) - Same methods as detailed under e - (1) and (2).
3 - Study of reared and pinned parasites in collections.
(1) - Systematic grouping of specimens.
(2) - Preparation for reference to group specialists in National Museum or elsewhere.

B - Parasites (Investigations in Europe).
Note: Dr. Thompson, Dr. Parker and assistants.

1 - Collection of material for study.
a - Parasite cocoons or puparia
(1) - Study of species hibernating as above.
(2) - Biology, hyperparasites, interrelations, economic status, etc.
b - Host larvae and pupae.
(1) - Dissections of larvae from various areas.
(a) - Study of species present, their determination, relationships, etc.
(b) - Optimum areas of parasitism determined as above.
(2) - Adult parasites reared from above are studied as in 1-a-(1) and (2).
2 Collection of material for shipment to Arlington, Mass., laboratory.
a - Select best areas for collections based upon data secured from dissections. (Four such areas are outstanding in France and one area in Italy.
b - Establish trained supervising collectors in each area.
(1) - Hire necessary local collectors.
c - Select local sites from which collections are made.
3 - Method of sending material to Arlington, Mass.
a - Species hibernating in cocoon stage sent to Paris, held under refrigeration until sent to New York under refrigeration. Met at boat by Arlington representative and taken to Arlington.
b - Host larvae, some of which contain internal parasites, mailed direct to Arlington in lots of from 2,000 to 10,000.

c - Summer collections handled similar to above.
4 - Study of conditions in different areas under observation.
a - Biology of host.
b - Host plants.
c - Reaction to ecological conditions.
d - Reaction to widely different types of agriculture.
e - Control methods observed and their value.
5 - Cooperation with K. W. Babcock as indicated under Section VI
6 - Miscellaneous cooperation re parasites of alfalfa weevil, elm-leaf beetle and European earwig.
C - Parasites (Investigations in Orient)
1 - Procedure indicated under section VII.
2 - Continuation of parasite shipments according to results of investigations to determine species present in the Orient, their biology interrelationships, economic status etc. Preliminary shipments received late in season of 1926.
D - Predators.
1 - Insects. 2 - Spiders. 3- Birds. 4- Animals.
a - Continuation of studies relating to the economic status of each of the above as natural enemies of the corn borer.

IX - Disease.

A - Casual observations re death of larvae from disease.
1 - In the field. 2 - In rearing cages.
a - Refer such specimens to specialists for determination.

X - Miscellaneous.
A - Laboratory Methods and Technique.
1 - Continuation of studies to develope rearing cages. for eggs, larvae, pupae and adults.
2 - Incubators and other conditioning apparatus.
3 - Large field cages for transfer experiments.
B - Taxonomy and Exhibition.
1 - Preparation and preservation of material for exhibition or study.
a - All stages of the corn borer and associated insects.
b - Typical samples illustrating injury to host plants.
2 - Preparation of exhibit cases, Riker mounts, etc. as indicated under B-1.
3 - Arrangement and care of working collection.
a - Corn borer and associated insects of the group.
b - Parasites.
C - Statistics.
1 - Crop losses.
a - Corn.
b - Other economic crops attacked.
2 - Corn acreages and value of crops.
3 - Weather reports and other meteorological data.
4 - Maps.
D - Photography.
A - Photographs of
1 - Apparatus and experimental equipment.
2 - Drawings, maps, charts signs etc.
3 - Infested plants, and portions thereof, showing typical injury and life stages in situ.
4 - Parasites and technique employed.
5 - Associated insects and their typical work.

XI - Appendix - Projects completed or suspended.

A - Control.

1 - Burning infested material by use of oil torch; flame; power pump; incinerator; in piles-using wood, oil, brush etc as fuel.
2 - Steaming infested material with portable boiler; with collecting vehicle and under partial vacuum.
3 - Crushing infested material with special machine designed for this purpose; with heavy roller; with tractor; and with disc harrow.
4 - Burying infested material in manure and compost.
5 - Plowing under infested material. Detailed studies of the reaction of larvae and pupae when plowed under, or hand-buried, in the Summer, Autumn and Spring in soils of various types and under varying conditions of soil temperature and soil moisture.
6 - Feeding infested material to livestock. Detailed studies pertaining to the mortality of larvae and pupae and suitability of treated material as food when cut by various types of ensilage cutters.
7 - Insecticides. Detailed studies pertaining to the effect of various poison sprays and dusts when directed against the eggs, larvae, pupae and adults of the corn borer - as applied to growing corn, vegetables and flowers.
8 - Herbicides. Use of standard and specially prepared herbicides directed against susceptible weed hosts of the corn borer to determine effect on eggs, larvae and pupae within the treated weeds; the killing effect on the weeds; effect on subsequent flora of treated areas with special reference to plants not hosts of the corn borer.
9 - Fumigants. Effect of various fumigants under atmospheric pressures, and under partial vacuumm when directed against infested broom corn, cornstalks and corn on cob. Effect of such treatment on germination of seed and subsequent development of plant.
10 - Heating infested material. Effect of heating infested ear-corn and broom-corn under varying conditions of container temperature and humidity, and under various conditions of exposure. Effect of such treatment on germination of seed and subsequent development of plant.
11 - Special plantings and field observations to determine possible utility of early plantings of sweet corn as trap crops.
12 - Special plots and field observations to determine status of various economic field crops, vegetables and flowers as hosts of the corn borer and to determine the status of the commercial products of each under quarantine restrictions.
13 - Use of hogs, sheep, goats, cattle, horses and chickens as possible aids in cleaning-up infested cornfields and weed areas.
14 - Planting obnoxious or toxic plants with corn to repel P. nubilalis.

B - Life-History, Seasonal History and Habits.

1 - Detailed studies of the duration and description of stages (egg, larva , pupa, adult) under varying conditions of temperature and moisture.
2 - Miscellaneous and detailed studies of larval habits, including fertility, hatching, establishment, molting, feeding, duration of life without food, adaptability to unusual hosts, migration, hibernation, mortality, reactions to air, soil and water, gregariousness, tropisms, spinning, cannabalism.

3 - Miscellaneous and detailed studies of adult habits including copulation, oviposition, tropisms (lights, baits, assembly, etc.), flight, feeding, reactions to air, soil, and water.
4 - Special project to determine distance of dispersion by flight and the influences responsible for such dispersion.
5 - Special project to determine distance of dispersion by water-drift of infested material and the influences responsible for such dispersion.
6 - Relation of artificial and common carrier to dispersion.
7 - Relation of constant and variable temperatures and humidities to the oviposition and duration of life of adult.
8 - Relation of temperature and precipitation to seasonal development/including experiments to determine correlations of the development of the egg, larva, and pupa at various constant temperatures; threshold of development; critical points in the developmental range of temperature (death points, optimum, maximum and minimum rates); effectiveness of constant and variable temperatures upon development; accumulated temperatures above various thresholds of development from 45° to 54° Fahr.; construction of velocity curves of development for egg, larva, and pupa; relation of temperature to size, color, and markings of adult; importance of hibernation in its relation to future development; effect of winter precipitation upon future seasonal history and development; state of hibernation; and hibernation quarters in relation to the emergence from hibernation.
9 - Hibernation experiments, including a study of the manner and ease with which hibernation may be broken up; the need for temperatures below the "actual" threshold of development; the emergence from hibernation; and, the rearing of resulting progeny under field conditions, from material which had been subjected to successive periods of abnormal hibernation conditions.
10 - Statistical study of meteorological records, and other environmental surroundings, of typical localities within the world distribution of the corn borer and the construction of hythergraphs of such localities for comparison with accompanying seasonal histories of the corn borer. To forecast the probable seasonal history (number of generations) in localities/of the U.S. not then infested by the insect.
11 - Study of possible symbiotic interference with seasonal history in various environments.
12 - Special project to determine comparative winter mortality under various environments.
13 - Effects of local physical/features and terrain on dispersion.

C - Host Plants.
1 - Seasonal abundance of the insect in each of the more important host plants.
2 - Specific determination of each host and host plant listed.
3 - Detailed investigation of all suspected greenhouse plants likely to enter commerce and the possibility of a third generation of the corn borer developing therein.

D - Histology.
1 - Studies of internal and external anatomy of egg, larva, pupa, and adult.
2 - Study of progressive structural changes taking place within the egg and pupa.
3 - Brief study of sections of male and female moths with special emphasis upon the reproductive organs.
4 - Special studies to determine structural reasons why overwintering larvae of corn borer do not feed prior to pupation.
5 - Special studies to ascertain possibility of existing differences in internal or external anatomy of larvae from one and from two generation areas.
6 - Special studies to determine the function of the tracheal closing apparatus of the larva with special reference to the ability of hibernating larvae to survive prolonged submergence in water and exposure to powerful fumigants.

E - Parasites.
1 - Histological study of the biology of Trichogramma minutum Riley as related to its parasitism of P. nubilali eggs.
2 - Extensive rearing and liberation campaigns on the two foreign parasites Exeristes roborator and Habrobracon brevicornis.

F - Predators.
1 - Special studies with infested cornstalks placed in selected localities to determine the statusof birds as predators in destroying the overwintering larvae. Determination of species of birds involved and assignment of relative value of each.
2 - Special project in cooperation with U. S. Biological Survey to determine status of birds as natural enemies of the corn borer - and the species of birds concerned.

G - Disease.
1 - Study to determine causative agent responsible for death of larvae killed by disease and the possibility of artificial cultivation and dissemination of such causative agent.

H - Laboratory Methods and Technique.
1 - Development ofmethods, cages and special apparatus for rearing material and conducting special investigation including cages, incubators, fumigatoriums, heating chambers, etc.

I - Taxonomy and Systematic.
1 - Detailed study of the morphology, biology, host plants, economic status and systematic relationship of the Genus Pyrausta, with especial reference to species associated with the corn borer. Including preparation of a key for their separation, based upon egg, larval, pupal or adult characteristics.

2 - General study of species of boring larvae resembling the corn borer. Including those species which resemble P. nubilalis in the appearance of their various stages or whose characteristic injury to their host plant resembles P. nubilalis.

J - Miscellaneous.
1 - Special study of relative economic status and habits of corn earworm when associated, in destructive numbers, with the corn borer.